

A new species of Music frog (Anura, Ranidae, *Nidirana*) from Mt Daming, Guangxi, China

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Academic editor: Anthony Herrel | Received 3 May 2021 | Accepted 30 July 2021 | Published 1 September 2021

<http://zoobank.org/207DB0D1-B593-4ACD-BF5A-A386AD89399E>

Citation: Lyu Z-T, Huang Z, Liao X-W, Lin L, Huang Y, Wang Y-Y, Mo Y-M (2021) A new species of Music frog (*Anura*, *Ranidae*, *Nidirana*) from Mt Daming, Guangxi, China. *ZooKeys* 1059: 35–56. <https://doi.org/10.3897/zookeys.1059.68140>

Abstract

Nidirana guangxiensis **sp. nov.**, a new music frog species, is proposed, based on a series of specimens collected from Mt Daming, Guangxi, southern China. The new species is close to *N. yeae*, *N. daunchina*, *N. yaoica*, and *N. chapaensis* from southwestern and south-central China and northern Indochina, while the relationships among these species remain unresolved. *Nidirana guangxiensis* sp. nov. can be distinguished from all known congeners by the genetic divergences in the mitochondrial 16S and COI genes, the behavior of nest construction, the advertisement call containing 6–11 rapidly repeated regular notes, and a combination of morphological characteristics. Furthermore, the *Nidirana* populations recorded in Guangxi are clarified in this work, providing valuable new information on the knowledge of the genus *Nidirana*.

Keywords

Bioacoustics, geography, mitochondrial DNA, morphology, nest construction

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Introduction

The music frog genus *Nidirana* Dubois, 1992 was originally proposed as a subgenus of *Rana* Linnaeus, 1758. Later, *Nidirana* was controversially recognized as a full genus or a synonym of *Babina* Thompson, 1912 (Chen et al. 2005; Frost et al. 2006). Recently, comprehensive morphological, molecular, bioacoustic, and biogeographical evidence has resurrected *Nidirana* as a distinct genus (Lyu et al. 2017). The frogs of this genus usually inhabit the natural or artificial swamps, ponds, and paddy fields in the hilly regions of subtropical eastern and southeastern Asia, with some species having nest construction behavior when courting (Fei et al. 2009; Lyu et al. 2017). The known diversity of *Nidirana* increased dramatically from seven to 15 species since 2017 (Lyu et al. 2017, 2019, 2020a). Most of the newly described species were previously misidentified as other congeners, due to their conservative phenotypes (Lyu et al. 2019, 2020a, 2020b). For instance, Lyu et al. (2020b) revised multiple populations historically recorded as *Nidirana adenopleura* (Boulenger, 1909) from China. They suggested that only the populations from Taiwan, Jiangxi, Fujian, and southern Zhejiang are the true *N. adenopleura*, and nominated some other populations as three new species: *N. guangdongensis* Lyu, Wan & Wang, 2020, *N. mangveni* Lyu, Qi & Wang, 2020, and *N. xiangica* Lyu & Wang, 2020. Lyu et al.'s (2020b) work did not clarify all historic records of *N. adenopleura*, and the taxonomic status for the records not involved in their study remains unresolved.

The *Nidirana* populations in Guangxi Zhuang Autonomous Region, southern China, were previously recorded as *N. adenopleura* (Liu and Hu 1962; Zhang and Wen 2000; Fei et al. 2009; Mo et al. 2014). Fei et al. (2009) suspected this identification was not correct, but still tentatively followed it and suggested additional study. Recently, the population from Mt Dayao, eastern Guangxi, has been revealed as a new species, *N. yaoica* Lyu, Mo, Wan, Li, Pang & Wang, 2019, and the population from Mt Dupangling, northeastern Guangxi was assigned to *N. xiangica* (Lyu et al. 2019, 2020b). During our recent surveys in Guangxi, we collected a series of *Nidirana* specimens from Mt Daming (**MDM**), central Guangxi, and Mt Jiuwan (**MJW**), northern Guangxi (Fig. 1). After comprehensive analyses, the specimens from MJW are identified as *N. leishanensis* Li, Wei, Xu, Cui, Fei, Jiang, Liu & Wang, 2019, while the specimens from MDM are herein proposed as a new species.

Materials and methods

Phylogenetic analysis

Nine muscular samples of the unnamed species from Guangxi were used for molecular analysis, encompassing five samples from MDM and four from MJW. All samples were obtained from euthanized specimens and then preserved in 95% ethanol and stored at -40°C . In addition, 33 sequences from all known *Nidirana* species and two sequences from the outgroup, *Babina holsti* (Boulenger, 1892) and

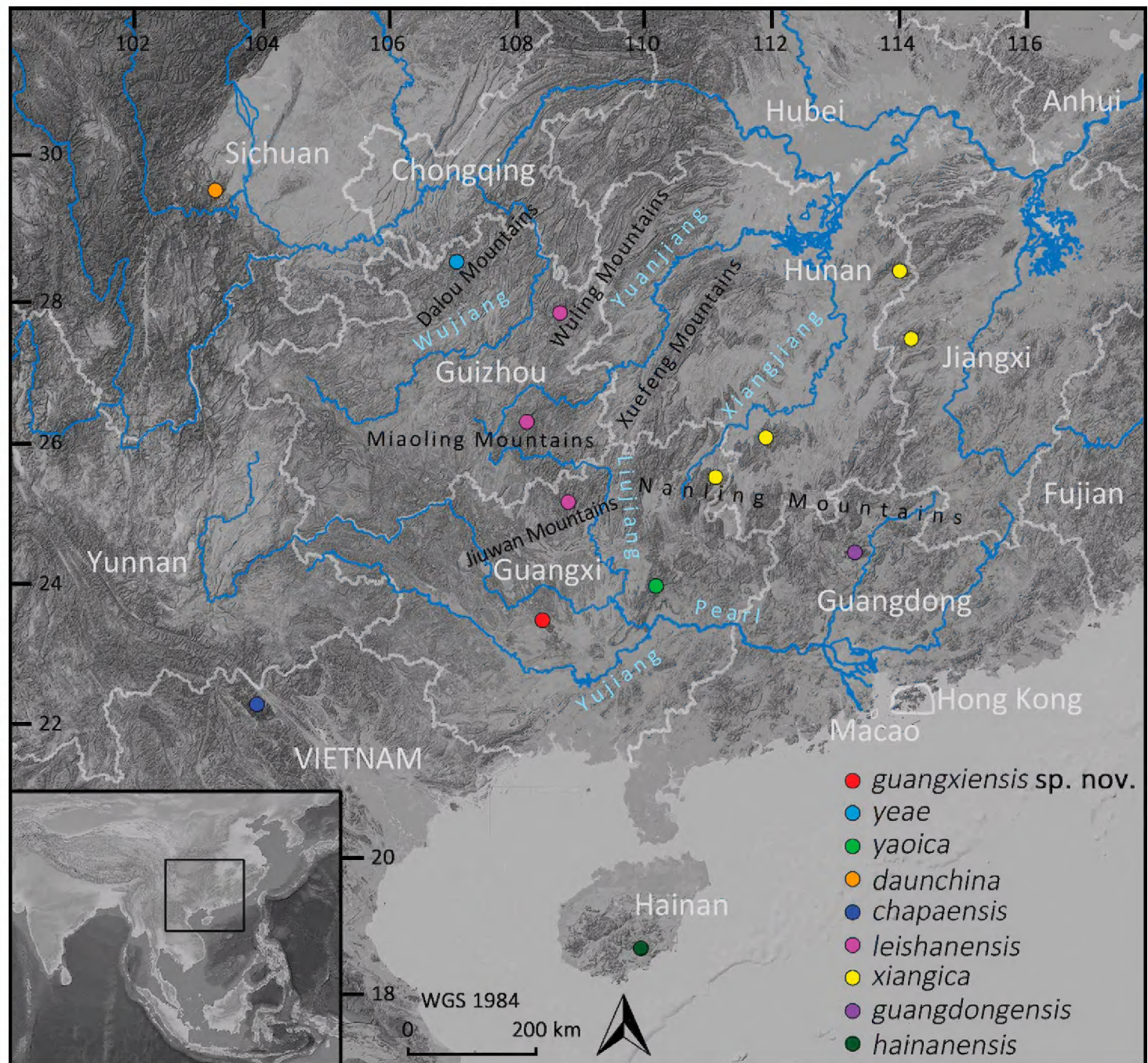


Figure 1. Map showing the collected localities for the *Nidirana* samples of Clade C (see Fig. 2) used in this study.

B. subaspera (Barbour, 1908) (following Lyu et al. 2017), were obtained from GenBank and incorporated into our dataset. Detailed information on these materials is shown in Table 1 and Figure 1.

Two mitochondrial genes, namely partial 16S ribosomal RNA gene (16S) and partial cytochrome c oxidase I gene (COI), were used for phylogenetic analysis. DNA extraction, PCR amplification, and sequencing conducted on the newly collected samples followed Lyu et al. (2019). Two gene segments, 1042 base pairs (bp) of 16S and 639 bp of COI, were concatenated seriatim into a 1681-bp matrix. The final alignment was partitioned by gene and COI was further partitioned by codon position. The partitions were tested in jmodeltest v. 2.1.2, resulting in the best-fitting nucleotide substitution models as GTR+I+G. Sequenced data were analyzed using maximum likelihood (ML) in RaxmlGUI v. 1.3 (Silvestro and Michalak 2012). The bootstrap consensus tree inferred from 1000 replicates was used to represent the evolutionary history of the taxa analyzed.

Table 1. Localities, voucher information, and GenBank numbers for all samples used in this study.

ID	Species	Locality	Voucher number	16S	COI
1	<i>Nidirana guangxiensis</i> sp. nov.	China: Guangxi: Mt Daming*	NHMG 202007001	MZ677222	MZ678729
2	<i>Nidirana guangxiensis</i> sp. nov.	China: Guangxi: Mt Daming*	NHMG 202007002	MZ677223	MZ678730
3	<i>Nidirana guangxiensis</i> sp. nov.	China: Guangxi: Mt Daming*	NHMG 202007003	MZ677224	MZ678731
4	<i>Nidirana guangxiensis</i> sp. nov.	China: Guangxi: Mt Daming*	NHMG 202007004	MZ677225	MZ678732
5	<i>Nidirana guangxiensis</i> sp. nov.	China: Guangxi: Mt Daming*	NHMG 202007005	MZ677226	MZ678733
6	<i>Nidirana yaoica</i>	China: Guangxi: Mt Dayao*	SYS a007020	MK882276	MK895041
7	<i>Nidirana yaoica</i>	China: Guangxi: Mt Dayao*	SYS a007021	MK882277	MK895042
8	<i>Nidirana yaoica</i>	China: Guangxi: Mt Dayao*	SYS a007022	MK882278	MK895043
9	<i>Nidirana leishanensis</i>	China: Guangxi: Mt Jiuwan	NHMG 202007021	MZ677227	MZ678734
10	<i>Nidirana leishanensis</i>	China: Guangxi: Mt Jiuwan	NHMG 202007022	MZ677228	MZ678735
11	<i>Nidirana leishanensis</i>	China: Guangxi: Mt Jiuwan	NHMG 202007023	MZ677229	MZ678736
12	<i>Nidirana leishanensis</i>	China: Guangxi: Mt Jiuwan	NHMG 202007025	MZ677230	MZ678737
13	<i>Nidirana leishanensis</i>	China: Guizhou: Mt Leigong*	SYS a007908	MN946453	MN945209
14	<i>Nidirana leishanensis</i>	China: Guizhou: Mt Fanjing	SYS a007195	MN946454	MN945210
15	<i>Nidirana xiangica</i>	China: Guangxi: Mt Dupangling	SYS a006568	MN946442	MN945198
16	<i>Nidirana xiangica</i>	China: Hunan: Mt Dawei*	SYS a006492	MN946434	MN945190
17	<i>Nidirana xiangica</i>	China: Hunan: Mt Yangming	SYS a007273	MN946440	MN945196
18	<i>Nidirana xiangica</i>	China: Jiangxi: Mt Wugong	SYS a002590	MN946441	MN945197
19	<i>Nidirana yeae</i>	China: Guizhou: Tongzi County	CIB TZ20190608004	MN295227	MN295233
20	<i>Nidirana yeae</i>	China: Guizhou: Tongzi County	CIB TZ20190608005	MN295228	MN295234
21	<i>Nidirana yeae</i>	China: Guizhou: Tongzi County	CIB TZ20160714016	MN295231	MN295237
22	<i>Nidirana adenopleura</i>	China: Taiwan: Taichung City	SYS a007358	MN946445	MN945201
23	<i>Nidirana adenopleura</i>	China: Taiwan: Taichung City	SYS a007359	MN946446	MN945202
24	<i>Nidirana chapaensis</i>	Vietnam: Lao Cai: Sapa*	MNHN 2000.4850	KR827711	KR087625
25	<i>Nidirana chapaensis</i>	Vietnam: Lao Cai: Sapa*	MNHN 1999.5871	KR827710	/
26	<i>Nidirana daunchina</i>	China: Sichuan: Mt Emei*	SYS a004594	MF807822	MF807861
27	<i>Nidirana daunchina</i>	China: Sichuan: Mt Emei*	SYS a004595	MF807823	MF807862
28	<i>Nidirana guangdongensis</i>	China: Guangdong: Yingde City*	SYS a005767	MN946406	MN945162
29	<i>Nidirana guangdongensis</i>	China: Guangdong: Yingde City*	SYS a005768	MN946407	MN945163
30	<i>Nidirana hainanensis</i>	China: Hainan: Mt Diaoluo*	SYS a007669	MN946451	MN945207
31	<i>Nidirana hainanensis</i>	China: Hainan: Mt Diaoluo*	SYS a007670	MN946452	MN945208
32	<i>Nidirana lini</i>	China: Yunnan: Jiangcheng County*	SYS a003967	MF807818	MF807857
33	<i>Nidirana lini</i>	China: Yunnan: Jiangcheng County*	SYS a003968	MF807819	MF807858
34	<i>Nidirana mangveni</i>	China: Zhejiang: Mt Dapan*	SYS a006310	MN946424	MN945180
35	<i>Nidirana mangveni</i>	China: Zhejiang: Mt Dapan*	SYS a006311	MN946425	MN945181
36	<i>Nidirana nankunensis</i>	China: Guangdong: Mt Nankun*	SYS a005718	MF807839	MF807878
37	<i>Nidirana nankunensis</i>	China: Guangdong: Mt Nankun*	SYS a005719	MF807840	MF807879
38	<i>Nidirana occidentalis</i>	China: Yunnan: Mt Gaoligong*	SYS a003775	MF807816	MF807855
39	<i>Nidirana occidentalis</i>	China: Yunnan: Mt Gaoligong*	SYS a003776	MF807817	MF807856
40	<i>Nidirana okinavana</i>	Japan: Okinawa: Iriomote Island*	Not given	NC022872	NC022872
41	<i>Nidirana pleuraden</i>	China: Yunnan: Kunming City*	SYS a007858	MT935683	MT932858
42	<i>Nidirana pleuraden</i>	China: Yunnan: Wenshan City	SYS a007717	MT935671	MT932850
43	<i>Babina holsti</i>	Japan: Okinawa*	Not given	NC022870	NC022870
44	<i>Babina subaspera</i>	Japan: Kagoshima: Amami Island*	Not given	NC022871	NC022871

* Type locality.

Morphological examination

Seventeen male and two female unnamed specimens collected from MDM were examined and measured, collection information is given in the taxonomic proposal. All specimens were fixed in 10% buffered formalin, transferred to 70% ethanol, and deposited in the Natural History Museum of Guangxi (NHMG) and the Museum of Biology, Sun Yat-sen University (SYS), China.

Morphological descriptions follow the consistent definition by Lyu et al. (2017, 2019, 2020a, 2020b). External measurements of specimens were made with digital

calipers (Neiko 01407A stainless steel 6-inch digital calipers) to the nearest 0.1 mm. These measurements are as follows:

SVL	snout-vent length (from tip of snout to posterior margin of vent);
HDL	head length (from tip of snout to the articulation of the jaw);
HDW	head width (head width at the commissure of the jaws);
SNT	snout length (from tip of snout to the anterior corner of the eye);
IND	internasal distance (distance between nares);
IOD	interorbital distance (minimum distance between upper eyelids);
ED	eye diameter (from the anterior corner of the eye to posterior corner of the eye);
TD	tympanum diameter (horizontal diameter of tympanum);
TED	tympanum-eye distance (from anterior edge of tympanum to posterior corner of the eye);
HND	hand length (from the proximal border of the outer palmar tubercle to the tip of digit III);
RAD	radio-ulna length (from the flexed elbow to the proximal border of the outer palmar tubercle);
FTL	foot length (from distal end of shank to the tip of digit IV);
TIB	tibial length (from the outer surface of the flexed knee to the heel).

Sex and age were determined by examining the gonads. Webbing formula follows Savage (1975).

Comparison characters of all known congeners were obtained from 129 museum specimens of 12 known congeners listed in the Appendix 1 and from the literature (Boettger 1895; Boulenger 1904, 1909; Schmidt 1925; Chang and Hsu 1932; Bourret 1937; Kuramoto 1985; Chou 1999; Fei et al. 2007, 2009; Matsui 2007; Chuaynkern et al. 2010; Lyu et al. 2017, 2019, 2020a, 2020b; Li et al. 2019; Wei et al. 2020).

Particularly, since the new *Nidirana* species from MDM is geographically and phylogenetically close to *N. yaoica*, and phylogenetically close to *N. yeae* Wei, Li, Liu, Cheng, Xu & Wang, 2020, enhanced morphometric data of these three species were used for statistical analyses in R v. 4.0.0. Due to the limited number of females collected, only male specimens were used. Data of the MDM specimens were newly measured in this work; meanwhile data of *N. yaoica* and *N. yeae* were obtained from the literature (Lyu et al. 2019; Wei et al. 2020). All measurements were ln-transformed to normalize and reduce the variance. The *t*-test was conducted with statistically similar variances ($p > 0.05$ in the Levene's test) using car R package. Boxplots were visualized with the "ggplot2" R packages. For *t*-test and boxplots, measurements were scaled to remove allometric effects of body size in morphological analysis, using the following equation: $X_a = X_{ln} - \beta \cdot (SVL_{ln} - SVL_m)$, where X_a = adjusted value; X_{ln} = ln-transformed measurements; β = unstandardized regression coefficient for each species; SVL_{ln} = ln-transformed SVL; and SVL_m = overall average SVL_{ln} of all samples. Principal component analysis (PCA) was performed to reduce the dimensionality of variation in the data to find whether morphological variation form the basis of detectable group structure, using the "prcomp" function and "ggplot2" package.

Bioacoustic analysis

Advertisement calls of the *Nidirana* population from MDM were recorded in the field at the air temperature of 18 °C by a Sony PCM D100 digital sound recorder on 20 April 2021. The recorded individuals were observed to ensure as the correct species but were not captured for conservation reasons. The sound files in wave format were sampled at 44.1 kHz with 24 bits in depth. Praat v. 6.0.27 (Boersma 2001) was used to obtain the oscillogram, sonogram, and power spectrum (window length = 0.005 s). Raven Pro v. 1.5 (Cornell Lab of Ornithology 2003–2014) was used to quantify the acoustic properties (window size = 256 points, fast Fourier transform, Hanning window with no overlap). The call duration (the time between onset of the first note and offset of the last note in a call) and call PF (peak frequency; the frequency at which max power occurs within the call) were measured for each call, and the note duration (the time between onset and offset of a note) and note interval (the time between adjacent notes in a call) were measured for each note.

Results

Phylogeny

The result of ML analysis was given in Figure 2, in which the supportive nodes with the bootstrap supports (BS) > 90 were shown. This mitochondrial result is consistent with the phylogenetic relationship from previous studies (e.g. Lyu et al. 2020a), with two species groups and four clades revealed. The *Nidirana* populations from MDM (ID 1–5) and MJW (ID 9–12) are both inserted in the Clade C (clade names following Lyu et al. 2017) of the *N. adenopleura* group, which are distant from the true *N. adenopleura* in Clade D in phylogeny. Within Clade C, the *Nidirana* population from MJW (ID 9–12) is clustered with samples of *N. leishanensis* from Mt Leigong and Mt Fanjing, Guizhou, with strong supports (BS = 100) and small divergences, which indicates the MJW population should be clarified as *N. leishanensis*. The *Nidirana* population from MDM (ID 1–5) forms an independent lineage with strong supports (BS = 100) and almost no divergence, which is close to but diverse from the lineages of *N. yeae*, *N. daunchina* (Chang, 1933), *N. yaoica*, and *N. chapaensis* (Bourret, 1937). The relationship among these five lineages remains unresolved, even though the MDM population seems closer to *N. yeae* with medium support (BS = 92).

Morphology

Detailed comparisons among all *Nidirana* species are listed in Table 2, which shows the distinct differences of the *Nidirana* specimens from MDM (detailed comparisons presented in the Taxonomic proposal below). The results of *t*-test and boxplots of morphometrics (Table 3; Fig. 3) show that the *Nidirana* specimens from MDM are

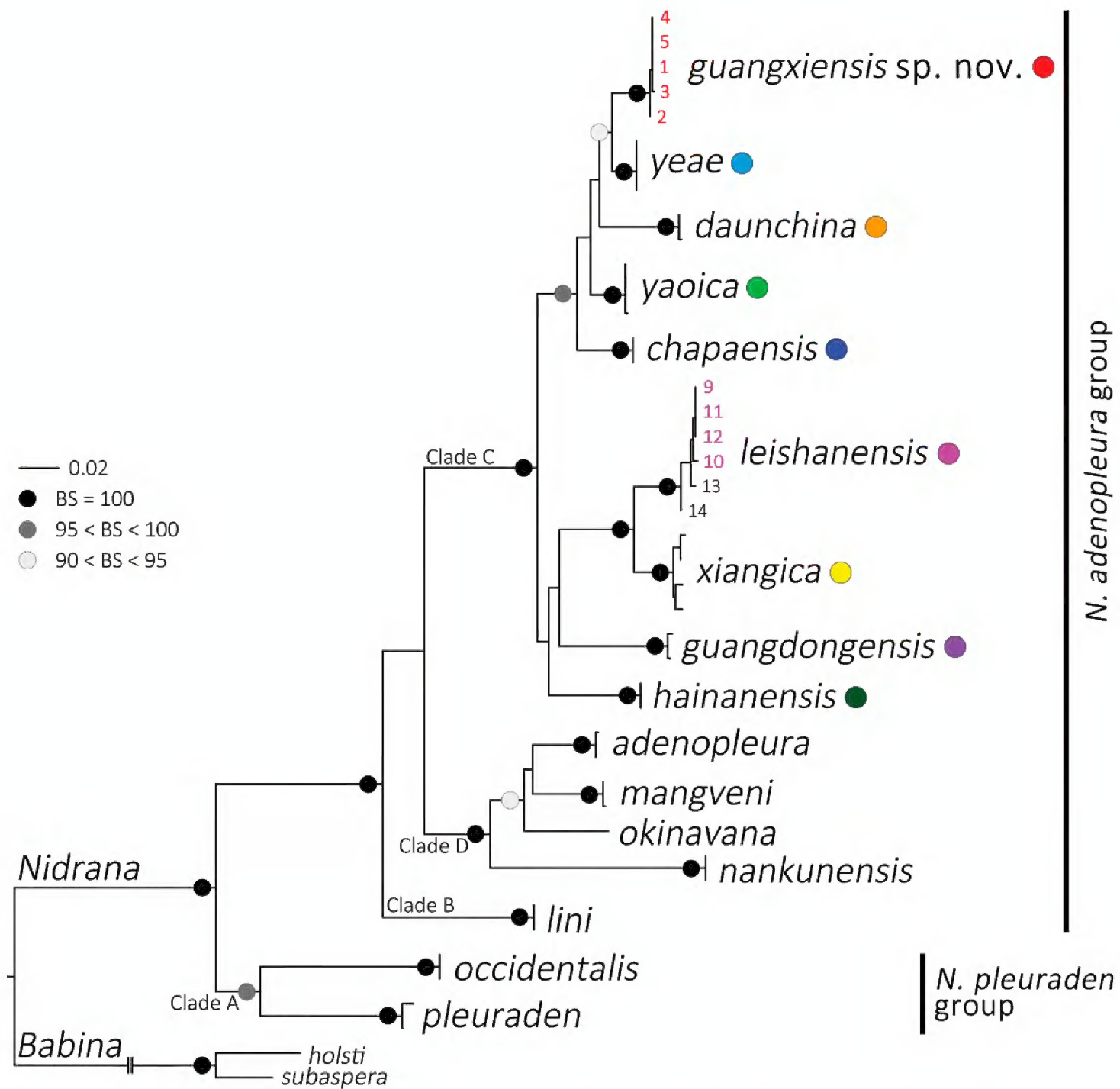


Figure 2. Phylogeny of *Nidirana* based on maximum likelihood. Number at the terminal of the branches corresponds to the ID number in Table 1.

significantly different from *N. yeae* from northern Guizhou, especially in the characteristics of HDL, HDW, IND, TD, RAD, FTL, and TIB, and different from *N. yaoica* from eastern Guangxi in the characteristics of HDL, HDW, SNT, ED, TD, and RAD. In the PCA analyses (Fig. 4), the extracted components PC1, PC2, PC3, and PC4 eigenvectors account for 46.4%, 17.5%, 11.7%, and 8.3% of the variance, respectively, or 83.9% cumulatively. As illustrated in the scatter plots of PC1 and PC2, samples of each species cluster together and do not overlap with each other.

Bioacoustics

The advertisement calls of three male individuals of the *Nidirana* population from MDM are recorded, and the call spectrograms are shown in Figure 5. The advertisement

Table 2. Diagnostic characters separating *Nidirana guangxiensis* sp. nov. from all congeners.

Species	SVL of males (mm)	SVL of females (mm)	Fingers tips	Lateroventral groove on fingers	Relative length of fingers	Toes tips	Lateroventral groove on toes	Tibio-tarsal articulation	Subgular vocal sacs	Nuptial pad	Spinules on dorsal skin	Nest construction	Tadpole labial tooth row formula	Calling	References
<i>N. guangxiensis</i>	40.2–47.6	49.9–51.0	Dilated	Present on fingers III and IV	II < I < IV < III	Dilated	Present	Nostril	Present	One on finger I	Absent	Present	I: 1+1/1+1:II	6–11 rapidly repeated regular notes	This study
<i>N. yae</i>	41.2–43.5	44.7	Dilated	Absent	II < IV < I < III	Dilated	Present	Eye	Present	One on finger I	Absent	? (Probably absent)	I: 1+1/1+1:II	2–6 notes containing a specific first note	Wei et al. (2020)
<i>N. yaoica</i>	42.1–45.6	?	Dilated	Present	II < I < IV < III	Dilated	Present	Nostril	Present	One on finger I	Absent	? (Probably present)	?	1–3 fast-repeated regular notes	Lyu et al. (2019)
<i>N. daunchina</i>	40.6–51.0	44.0–53.0	Dilated	Absent or rarely present	II < I < IV < III	Dilated	Present	Nostril	Present	One on finger I	Absent	Present	I: 1+1/1+1:II or I: 1+1/2+2:I	2–5 notes containing a specific first note	Liu (1950); Lyu et al. (2017)
<i>N. chapaensis</i>	35.5–42.5	41.0–51.8	Dilated	Present except finger I	II < I = IV < III	Dilated	Present	Nostril	Present	Two on finger I	Absent or few above vent	Present	I: 1+2/1+1:II	3 notes	Chuaynkern et al. (2010)
<i>N. adenopleura</i>	43.1–57.6	47.6–60.7	Dilated	Present except finger I	II < I < IV < III	Dilated	Present	Snout tip or eye-snout	Present	One on finger I	Entire or posterior	Absent	I: 1+1/1+1:II or I: 0+0/1+1:I	2–5 regular notes	Lyu et al. (2017, 2020b)
<i>N. guangdongensis</i>	50.0–58.4	55.3–59.3	Dilated	Present except finger I	II < I < IV < III	Dilated	Present	Nostril	Present	One on finger I	Entire	Absent	?	2–4 regular notes	Lyu et al. (2020b)
<i>N. hainanensis</i>	32.8–44.4	?	Dilated	Present	II < I < IV < III	Dilated	Present	Nostril	Present	Absent	Absent	Present	?	2–4 fast-repeated double-notes	Fei et al. (2009, 2012)
<i>N. leishanensis</i>	49.5–56.4	43.7–55.3	Dilated	Present	II < IV < I < III	Dilated	Present	Eye-snout	Present	Two on fingers I and II	Absent	Absent	I: 1+2/ 1+1:II	1 single note	Li et al. (2019)
<i>N. lini</i>	44.1–63.1	57.7–68.6	Dilated	Present except finger I	II < I < IV < III	Dilated	Present	Beyond snout	Present	One on finger I	Posterior	Absent	I: 1+1/1+1:II	5–7 notes containing a specific first note	Chou (1999); Lyu et al. (2017)
<i>N. mangveni</i>	53.6–59.7	59.7–65.1	Dilated	Present on fingers III and IV	I < II < IV < III	Dilated	Present	Anterior corner of eye	Present	One on finger I	Entire or posterior	Absent	?	2–7 regular notes	Lyu et al. (2020b)
<i>N. nankunensis</i>	33.3–37.1	37.8–39.5	Dilated	Present except finger I	II < I < IV < III	Dilated	Present	Nostril	Present	One on finger I	Absent or few above vent	Present	I: 1+1/1+1:II	13–15 notes containing a specific first note	Lyu et al. (2017)
<i>N. occidentalis</i>	44.5–53.0	55.6–61.3	Not dilated	Absent	II < I < IV < III	Not dilated	Absent	Eye	Present	One on finger I	Posterior	Absent	?	3–5 regular notes	Lyu et al. (2020a)
<i>N. okinavana</i>	35.5–42.8	44.6–48.8	Dilated	Present except finger I	II < I < IV < III	Dilated	Present	Eye center-near nostril	Absent	Poorly one on finger I	Absent	Present	I: 1+1/1+1:II	10–25 fast-repeated notes	Chuaynkern et al. (2010); Lyu et al. (2017)
<i>N. pleuraden</i>	46.2–52.3	46.9–61.7	Not dilated	Absent	II < I < IV < III	Not dilated	Absent	Nostril	Present	One on finger I	Posterior	Absent	I: 1+1/1+1: II	1–4 regular notes	Lyu et al. (2017, 2020a)
<i>N. xiangica</i>	56.3–62.3	53.5–62.6	Dilated	Present	II < I < IV < III	Dilated	Present	Eye-snout	Present	One on finger I	Entire	Absent	?	2–3 notes containing a specific first note	Lyu et al. (2020b)

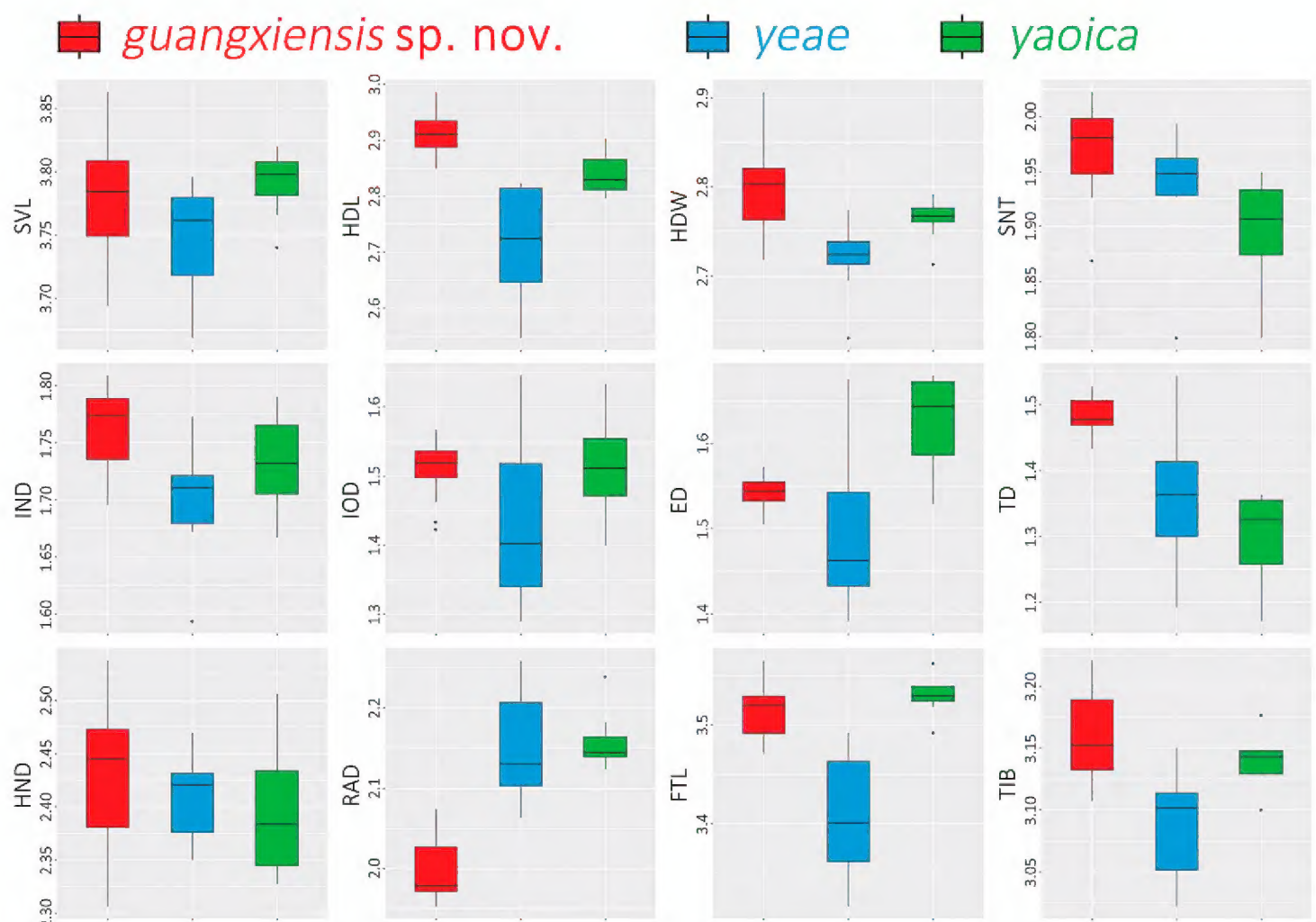


Figure 3. Boxplots of morphometrics based on the morphometric measurements, distinguishing *Nidirana guangxiensis* sp. nov., *N. yaeae*, and *N. yaoica*.

Table 3. Morphometric comparisons based on the *t*-test of the morphometric measurements of males *Nidirana guangxiensis* sp. nov. (*N* = 17), *N. yaeae* (*N* = 9), and *N. yaoica* (*N* = 8). * *p*-values < 0.05, ** *p*-values < 0.01, *** *p*-values < 0.001.

	<i>guangxiensis</i>	<i>yaeae</i>	<i>yaoica</i>	<i>guangxiensis vs yaeae</i>	<i>guangxiensis vs yaoica</i>
SVL	40.2–47.6(43.8 ± 2.2)	39.2–44.5(42.4 ± 1.8)	42.1–45.6(44.3 ± 1.2)	0.1226	0.4136
HDL	17.1–19.9(18.5 ± 0.7)	12.8–16.8(15.0 ± 1.5)	16.3–18.6(17.3 ± 0.8)	0.0002 ***	0.0011 **
HDW	15.3–18.4(16.5 ± 0.8)	13.1–16.2(15.0 ± 0.8)	15.0–16.7(16.0 ± 0.6)	0.0002 ***	0.0232 *
SNT	6.4–7.8(7.2 ± 0.4)	5.7–7.3(6.8 ± 0.5)	6.2–7.2(6.7 ± 0.4)	0.1068	0.0031 **
IND	5.4–6.3(5.8 ± 0.2)	4.7–5.9(5.4 ± 0.3)	5.4–6.0(5.7 ± 0.2)	0.0040 **	0.1105
IOD	4.1–5.0(4.6 ± 0.2)	3.5–5.2(4.2 ± 0.6)	4.1–5.1(4.6 ± 0.3)	0.1730	0.8934
ED	4.5–4.9(4.7 ± 0.1)	4.0–5.2(4.5 ± 0.4)	4.6–5.4(5.1 ± 0.3)	0.1964	0.0068**
TD	4.2–4.7(4.4 ± 0.1)	3.3–4.7(3.9 ± 0.4)	3.2–3.9(3.7 ± 0.3)	0.0101*	0.0001***
HND	10.0–12.8(11.4 ± 0.8)	10.1–11.9(11.0 ± 0.5)	10.3–12.4(11.1 ± 0.8)	0.3092	0.2468
RAD	7.1–8.1(7.4 ± 0.3)	7.7–9.6(8.6 ± 0.7)	8.4–9.4(8.7 ± 0.3)	0.0001***	0.0000 ***
FTL	32.0–37.0(33.7 ± 1.3)	26.9–32.2(29.8 ± 1.9)	33.1–35.7(34.4 ± 0.8)	0.0006***	0.1439
TIB	21.9–25.2(23.7 ± 1.1)	19.6–22.8(21.5 ± 1.0)	22.6–23.9(23.3 ± 0.4)	0.0003***	0.0653

calls of the *Nidirana* population in MDM have the duration of 1.012–1.917 s (1.461 ± 0.29 , *N* = 20), with the PF of 1894.9 Hz generally, and consisted of 6–11 (8.4 ± 1.4 , *N* = 20) rapidly repeated notes. All notes are identical and regular, with the duration of 56–101 ms (77.4 ± 6.7 , *N* = 168) and the interval between them lasts for 70–183 ms (110.4 ± 21.36 , *N* = 147). The advertisement calls of the *Nidirana*

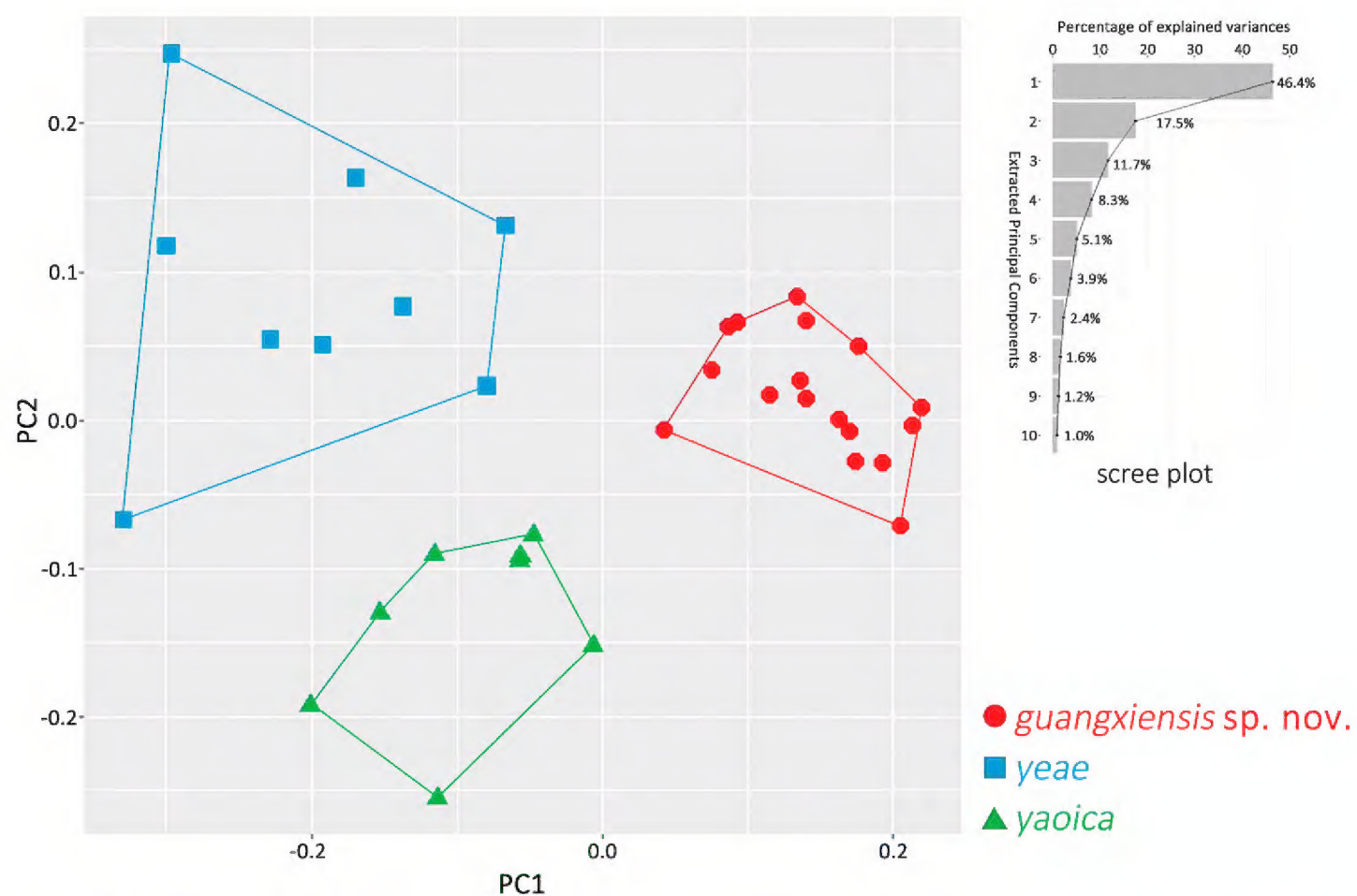


Figure 4. Scatter plot of PC1 and PC2 of principal component analysis based on the morphometric measurements, distinguishing *Nidirana guangxiensis* sp. nov., *N. yeae*, and *N. yaoica*.

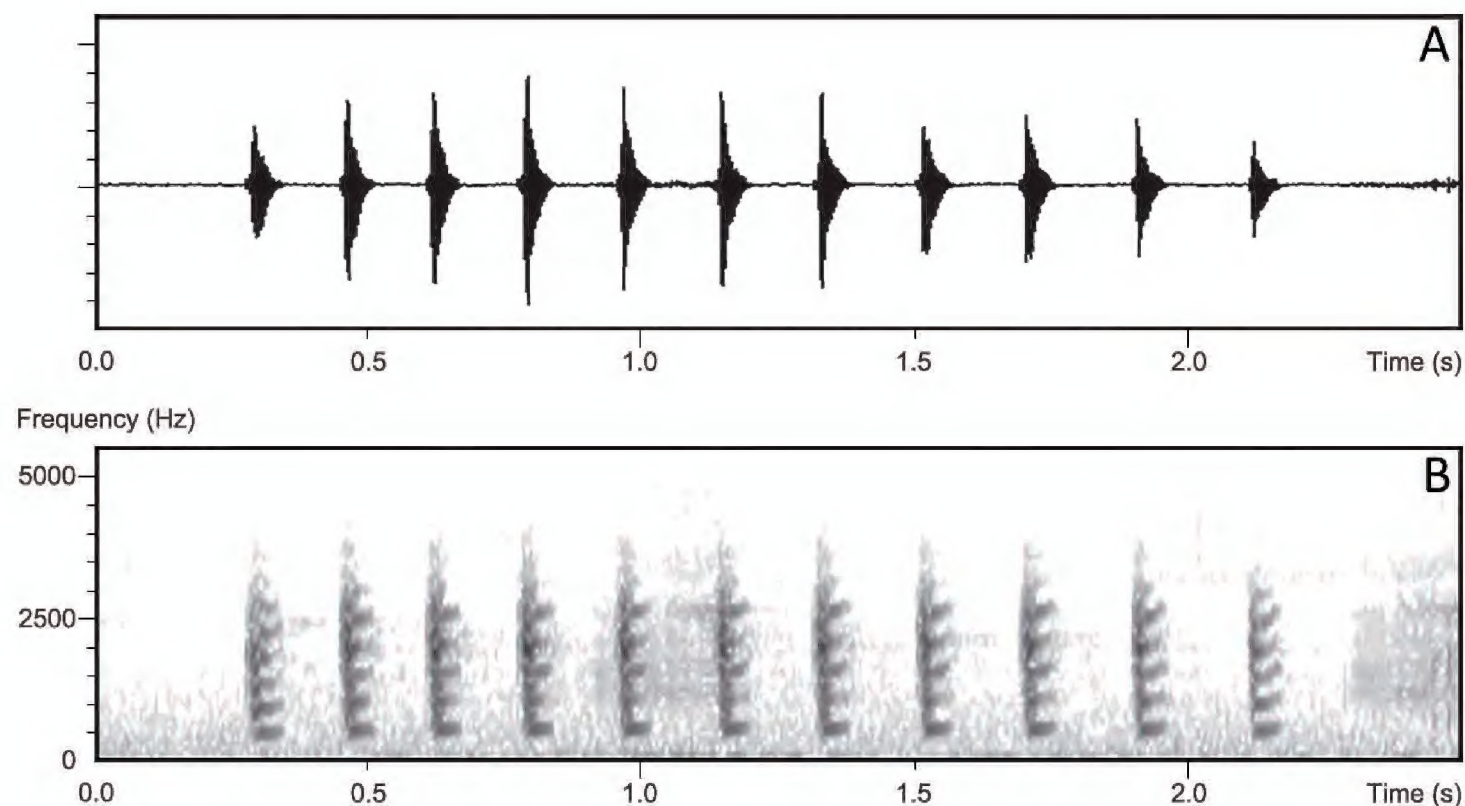


Figure 5. Advertisement call spectrograms of *Nidirana guangxiensis* sp. nov. **A** waveform **B** sonogram.

population in MDM are different from the congeners by (1) all notes in a call are identical and regular [vs containing a significantly different first note in *N. yeae*, *N. daunchina*, *N. lini* (Chou, 1999), *N. nankunensis* Lyu, Zeng, Wang, Lin, Liu & Wang,

2017, and *N. xiangica*; containing 2–4 fast-repeated double-notes in *N. hainanensis* (Fei, Ye & Jiang, 2007)]; (2) containing 6–11 notes in a call [vs containing less than 6 notes in *N. leishanensis*, *N. chapaensis*, *N. yaoica*, *N. adenopleura*, *N. guangdongensis*, *N. occidentalis* Lyu, Yang & Wang, 2020, and *N. pleuraden* (Boulenger, 1904)].

Taxonomic proposal

Based on the molecular, morphological, and bioacoustic differences, the population from MDM, Guangxi represents an unnamed species of genus *Nidirana* which is described here.

***Nidirana guangxiensis* Mo, Lyu, Huang, Liao & Wang, sp. nov.**

<http://zoobank.org/4E5C27A2-D398-4758-A181-BB49D1D5EF42>

Chresonymy.

Hylarana (*Hylarana*) *adenopleura* – Zhang and Wen 2000 (Mt. Daming, Guangxi)

Nidirana adenopleura – Mo et al. 2014 (Wuming and Shanglin, Guangxi)

Holotype. NHMG 202007003 (Figs 6, 7A, B), adult male, collected by Zhong Huang and Xiao-Wen Liao on 7 July 2020 from Mt Daming (23.5156°N, 108.4370°E; ca 1260 m a.s.l.), Wuming District, Nanning City, Guangxi Zhuang Autonomous Region, China.

Paratypes. Eighteen specimens. Female NHMG 202007001 (Fig. 7C), and males NHMG 202007002 (Fig. 7D), NHMG 202007004–005, 202007007–015, 202007019–020, collected at the same time with the holotype. Female SYS a008811/NHMG 202008003 and males SYS a008812–8813/NHMG 202008004–005, collected by Yun-Ming Mo, Zhong Huang, and Xiao-Wen Liao on 18 August 2020 from the same locality with the holotype.

Etymology. The specific name *guangxiensis* refers to the type locality of the new species in Guangxi Zhuang Autonomous Region. The Zhuang language, one of the official languages of Guangxi Zhuang Autonomous Region, is based on the dialect of Wuming, from where the new species was collected.

Common name. “Guangxi Music Frog” in English and “广西琴蛙 (guǎng xī qín wā)” in Chinese.

Diagnosis. *Nidirana guangxiensis* sp. nov. is placed in the genus *Nidirana* based on the morphological characteristics of the absence of the thumb-like structure on finger I, presence of well-developed dorsolateral folds, and the presence of suprabrachial glands in breeding males (Lyu et al. 2017). It is further assigned to the *N. adenopleura* group by the presence of lateroventral grooves on all toes (Dubois 1992; Lyu et al. 2019).

Nidirana guangxiensis sp. nov. is distinguished from its congeners by the following combination of the morphological characteristics: (1) body medium sized, with SVL 40.2–47.6 mm (43.8 ± 2.2 , $N = 17$) in adult males and 49.9–51.0 mm ($N = 2$) in



Figure 6. Morphological features of the adult male holotype NHMG 202007003 of *Nidirana guangxiensis* sp. nov. in preservative **A** dorsal view **B** ventral view **C** lateral view **D** right hand **E** right foot. Photos by Shuo Qi.

adult females; (2) disks of digits dilated, pointed; (3) lateroventral grooves present on fingers III and IV, and each toe; (4) relative finger length $II < I < IV < III$; (5) lateral fringes wide on inner sides of fingers II, III and IV but absent on finger I; (6) webbing formula on toes $I\ 2-2\frac{2}{3}\ II\ 2-3\ III\ 2\frac{1}{2}-3\frac{2}{3}\ IV\ 3\frac{2}{3}-2\frac{1}{2}\ V$; (7) tibio-tarsal articulation reaching at the nostril; (8) dorsal skin rough with dense granules, several tubercles on the posterior part, flanks, and dorsal hindlimbs, without spinules on the skin; (9) distinct supernumerary tubercles below the base of fingers III and IV, palmar tubercles prominent and distinct; (10) a pair of subgular vocal sacs present; (11) a single nuptial pad on the first finger, nuptial spinules invisible; (12) suprabrachial gland large; (13) nest construction behavior present; (14) calling consisting of 6–11 rapidly repeated regular notes.

Comparison. *Nidirana guangxiensis* sp. nov. can be significantly distinguished from all other recognized congeners by the combination of the following characteristics: (1) body medium-sized, SVL 40.2–47.6 mm ($N = 17$) in adult males and 49.9–51.0 mm ($N = 2$) in adult females [vs SVL < 38 mm in adult male *N. nankunensis*; SVL > 50 mm in adult male *N. guangdongensis*, *N. mangveni*, and *N. xiangica*; SVL < 45 mm in adult female *N. yae* and *N. nankunensis*; SVL > 53 mm in adult female *N. guangdongensis*, *N. lini*, *N. mangveni*, *N. occidentalis*, and *N. xiangica*]; (2) relative fingers length $II < I < IV < III$ [vs $II < IV < I < III$ in *N. yae* and *N. leishanensis*; $II < I$



Figure 7. Variation and colorations of *Nidirana guangxiensis* sp. nov. in life **A, B** male holotype NHMG 202007003 **C** female paratype NHMG 202007001 **D** male paratype NHMG 202007002 **E, F** uncaptured female and male individuals in the wild. Photos by Zhong Huang, Zhi-Tong Lyu, and Yun-Ming Mo.

= IV < III in *N. chapaensis*; I < II < IV < III in *N. mangveni*]; (3) lateroventral grooves present on fingers III and IV [vs absent on all fingers in *N. yae*, *N. occidentalis*, and *N. pleuraden*; present on all fingers in *N. yaoica*, *N. hainanensis*, *N. leishanensis*, and *N. xiangica*; present on all fingers except finger I in *N. chapaensis*, *N. adenopleura*, *N. guangdongensis*, *N. lini*, *N. nankunensis*, and *N. okinavana* (Boettger, 1895)]; (4) lateroventral grooves present on all toes [vs absent on all toes in *N. occidentalis* and *N. pleuraden*]; (5) tibio-tarsal articulation reaches the nostril [vs beyond the snout tip in *N. lini*; at the eye in *N. yae* and *N. occidentalis*]; (6) a single nuptial pad present on

finger I [vs nuptial pad absent in *N. hainanensis*; nuptial pad divided into two parts on finger I in *N. chapaensis*; two nuptial pads respectively on fingers I and II in *N. leishanensis*]; (7) a pair of subgular vocal sacs present in males [vs absent in *N. okinavana*]; (8) spinules on posterior dorsal skin absent [vs present in *N. adenopleura*, *N. lini*, *N. mangveni*, *N. occidentalis*, *N. pleuraden*, and *N. xiangica*].

Particularly, *Nidirana guangxiensis* sp. nov. is relatively close in phylogeny to *N. yae* from northern Guizhou, but it can be distinguished by: the relative fingers length $II < I < IV < III$ [vs $II < IV < I < III$ in *N. yae*]; lateroventral grooves present on fingers III and IV [vs absent on all fingers]; tibio-tarsal articulation reaches the nostril [vs at the eye]; lateral fringes wide on inner sides of fingers II, III and IV but absent on finger I [vs present only on fingers III and IV]; webbing formula on toes $I\ 2-2\frac{2}{3}\ II\ 2-3\ III\ 2\frac{1}{2}-3\frac{2}{3}\ IV\ 3\frac{2}{3}-2\frac{1}{2}\ V$ [vs $I\ 2-2\ II\ 1\frac{2}{3}-3\frac{1}{2}\ III\ 2\frac{1}{2}-3\frac{2}{3}\ IV\ 3\frac{2}{3}-2\ V$]; in males, head larger, HDL/SVL 0.42 ± 0.02 [vs 0.35 ± 0.03], HDW/SVL 0.38 ± 0.02 [vs 0.35 ± 0.01], radio-ulna length shorter, RAD/SVL 0.17 ± 0.01 [vs 0.20 ± 0.01], and foot length longer, FTL/SVL 0.78 ± 0.03 [vs 0.70 ± 0.05].

Description of holotype. NHMG 202007003 (Figs 6, 7A, B), adult male. Body medium-sized, SVL 43.8 mm; head relatively long and wide (HDL/SVL 0.42, HDW/SVL 0.36), longer than wide (HDW/HDL 0.86), flat above; snout rounded in dorsal and lateral views, slightly protruding beyond lower jaw, longer than horizontal diameter of eye (SNT/ED 1.57); canthus rostralis distinct, slightly curved inwards on the nostril; loreal region concave; nostril round, closer to the snout than to the eye; a longitudinal swollen mandibular ridge extending from below nostril through lower edges of eye and tympanum to above insertion of arm, where the ridge is intermittent, forming a maxillary gland and shoulder gland; supratympanic fold absent; interorbital space flat, narrower than internasal distance (IND/IOD 1.31), pineal ocellus invisible; pupil elliptical, horizontal; tympanum distinct, round, relatively large, TD/ED 0.98; vomerine ridge present, bearing small teeth; tongue cordiform, margin of the tongue notched; a pair of subgular vocal sacs present.

Forelimbs moderately robust, lower arm 0.17 of SVL and hand 0.27 of SVL; fingers thin, relative finger lengths $II < I < IV < III$; tip of each finger slightly dilated, forming rounded disks; lateroventral grooves on fingers III and IV, not meeting at the tip of disks; fingers free of webbing; lateral fringes present and distinct on inner and outer sides of fingers II, III and IV, but absent on finger I; subarticular tubercles prominent and rounded; supernumerary tubercles present below the base of fingers III and IV; palmar tubercles three, elliptic, large, prominent and distinct; a single nuptial pad on the dorsal surface of finger I, nuptial spinules invisible.

Hindlimbs robust, tibia 0.53 of SVL, and foot 0.76 of SVL; heels overlapping when hindlimbs flexed at right angles to axis of body; tibio-tarsal articulation reaching at the nostril when hindlimb is stretched along the side of the body; toes relatively long and thin, relative lengths $I < II < V < III < IV$; tip of each toe slightly dilated with remarkable elongated ventral callous pad, forming long and pointed disk; lateroventral grooves well developed on each toe, not meeting at the tip of disks; webbing moderate,

formula: I $1\frac{1}{3}$ –2 II $1\frac{1}{3}$ – $2\frac{1}{3}$ III $1\frac{2}{3}$ –3 IV $3\frac{1}{3}$ – $1\frac{1}{3}$ V; lateral fringes present on inner and outer sides of each toe, forming distinct dermal flap on the lateral edges of toes I and V; subarticular tubercles rounded, prominent; inner metatarsal tubercle elliptic, length triple width; outer metatarsal tubercle indistinct, small and rounded; tarsal folds present and tarsal tubercle absent.

Dorsal skin rough with dense granules, several tubercles on the posterior part, flanks, and dorsal hindlimbs, not bearing spinules on the skin; developed dorsolateral fold from posterior margin of upper eyelid to above groin but intermittent posteriorly; a large and smooth suprabrachial gland behind base of forelimb, prominent; weak longitudinal ridges on upper arms and slightly extending to lower arm; the dorsal surfaces of thigh and tibia relatively rough with tubercles, forming several longitudinal ridges. Ventral surface of throat, body, and limbs smooth; large flattened tubercles densely arranged on the rear of thigh and around vent.

Color of holotype. In life (Fig. 7A, B), dorsal surface of head and body brown; a longitudinal light brown mid-dorsal stripe faintly beginning from interorbital area, extending posteriorly to vent and become more distinct; several black spots on posterior dorsum of body; dorsolateral fold brown; upper flank brown with small black spots; lower flank light brown; suprabrachial gland yellowish brown. Dorsal forelimbs brown; dorsal hindlimbs brown, two olive crossbars on the thigh, three on the tibia, and three on the tarsus; irregular olive marks on dorsal toes. Loreal and temporal regions dark brown, tympanum pink; upper $\frac{1}{3}$ iris brownish white and lower $\frac{2}{3}$ iris reddish brown; maxillary gland and shoulder gland creamy white. Lips, throat, ventral surface of body and limbs creamy white; rear thigh tinged with pink and pale grey patches; ventral hand and foot pale white.

In preservative (Fig. 6), dorsal surface becomes dark brown with the mid-dorsal stripe and black spots more distinct; flank surface and the suprabrachial gland become pale; crossbars and marks on limbs dark brown; loreal and temporal regions dark brown; maxillary gland and shoulder gland more distinct; ventral surface pale grey; rear thigh and ventral foot become dark grey.

Variations. Measurements of type series are given in Table 4. All specimens were similar in morphology. Females are significantly larger than males, with relatively smoother skin and fewer tubercles on dorsum and flanks. The colorations vary from pale brown to reddish brown in individuals (Fig. 7C–F). The patterns of mid-dorsal stripes are also variable but always present.

Male secondary sexual characteristics. A pair of subgular vocal sacs, a pair of slit-like openings at posterior of jaw; a single light brown nuptial pad on the dorsal surface of finger I, nuptial spinules invisible; suprabrachial gland present.

Tadpole. Body length 19.1 mm and tail length 43.1 mm in the 37th stage tadpole SYS a008814 (Fig. 8); body oval, flattened above; snout rounded in dorsal aspect and profile; eyes lateral; labial tooth row formula: 1:1+1/1+1:2; spiracle on left side of body, directed dorsoposteriorly; tail depth larger than body depth; dorsal fin arising just before origin of tail, maximum depth near mid-length, tapering gradually to narrow pointed tip.

Table 4. Measurements (in mm) of the type series of *Nidirana guangxiensis* sp. nov., * for the holotype, M for male, and F for female.

	NHMG 202007002	NHMG 202007003*	NHMG 202007004	NHMG 202007005	NHMG 202007007	NHMG 202007008	NHMG 202007009	NHMG 202007010	NHMG 202007011	NHMG 202007012
Sex	M	M	M	M	M	M	M	M	M	M
SVL	45.4	43.8	44.0	47.6	44.5	41.7	44.0	44.1	47.5	42.6
HDL	18.2	18.4	17.8	19.6	18.4	17.4	19.9	19.1	19.6	17.1
HDW	15.5	15.9	15.7	17.0	16.6	16.4	18.4	17.0	17.5	15.3
SNT	7.4	7.4	6.9	7.6	7.1	6.7	7.6	7.3	7.8	6.4
IND	6.0	6.0	5.7	5.9	5.6	5.7	6.0	6.1	6.3	5.4
IOD	4.6	4.6	4.8	5.0	4.7	4.1	4.5	4.6	4.8	4.1
ED	4.6	4.7	4.6	4.8	4.8	4.6	4.7	4.7	4.9	4.6
TD	4.4	4.6	4.2	4.6	4.4	4.3	4.4	4.3	4.7	4.3
HND	11.6	11.9	11.3	12.8	11.8	10.5	11.6	11.6	12.4	10.6
RAD	7.5	7.2	7.8	7.8	7.2	7.1	7.2	7.2	8.1	7.2
FTL	33.2	33.4	32.6	37.0	33.2	33.2	34.0	35.6	34.7	33.7
TIB	23.7	23.4	23.4	25.2	24.8	22.2	22.5	25.2	25.2	23.1
	NHMG 202007013	NHMG 202007014	NHMG 202007015	NHMG 202007019	NHMG 202007020	SYS a008812 /NHMG 202008004	SYS a008813 /NHMG 202008005	NHMG 202007001	SYS a008811 /NHMG 202008003	
Sex	M	M	M	M	M	M	M	F	F	
SVL	40.2	43.2	41.5	42.5	40.3	45.1	46.5	49.9	51.0	
HDL	18.0	18.3	18.0	18.5	18.6	18.5	18.5	20.3	20.4	
HDW	15.8	16.2	16.2	16.7	17.0	16.1	17.1	18.7	18.8	
SNT	6.7	7.3	7.2	7.3	7.0	7.4	7.5	7.9	7.8	
IND	5.6	5.9	5.9	5.9	5.9	5.7	5.8	6.0	6.1	
IOD	4.4	4.3	4.4	4.6	4.6	4.6	4.6	4.7	5.0	
ED	4.5	4.7	4.6	4.7	4.7	4.8	4.6	5.1	5.2	
TD	4.3	4.5	4.3	4.5	4.4	4.6	4.3	4.2	4.2	
HND	10.3	10.0	11.6	11.7	12.2	11.0	11.2	12.1	12.1	
RAD	7.1	7.2	7.3	7.2	7.8	7.1	7.7	8.6	8.8	
FTL	32.0	32.7	33.7	33.8	32.4	32.8	35.1	37.5	39.5	
TIB	21.9	24.3	23.6	24.7	23.2	23.0	23.7	27.1	26.7	

Distribution and ecology. Currently, *Nidirana guangxiensis* sp. nov. is known only from the type locality, Mt Daming, which is located between Wuming District and Shanglin County, Nanning, Guangxi (Fig. 1). This species of frog can only be found in the alpine swamp and neighboring brushwood on the peak of Mt Daming. The estimated extent of occurrence is less than 500 km², and the estimated area of occupancy is less than 50 km². The swamp was surrounded by subtropical evergreen broadleaf forests (Fig. 9A). Sympatric frog species observed in the swamp are *Duttaphrynus melanostictus* (Schneider, 1799), *Gracixalus jinxiuensis* (Hu, 1978), *Kurixalus odontotarsus* (Ye & Fei, 1993), and *Polypedates mutus* (Smith, 1940).

Nidirana guangxiensis sp. nov. was observed to have nest construction behavior. The nest is in the form of a mud burrow ca 25–30 mm in diameter and near the roots of plants. The top of the nest is open and may fill with water during the rainy season (Fig. 9B). From April to August, males call from dusk to midnight in the nest. In late April, tadpoles at the 26th–42nd stages can be observed, with the majority at the 33rd–37th stages.



Figure 8. Tadpole SYS a008814 of *Nidirana guangxiensis* sp. nov. Photos by Shuo Qi.

Discussion

With this work, the historically recorded populations of *Nidirana adenopleura* from Guangxi, are all reassigned to other recently described species, namely *N. yaoica* from Mt Dayao in the east, *N. xiangica* from Mt Dupangling in the northeast, *N. leishanensis* from Mt Jiuwan in the north, and *Nidirana guangxiensis* sp. nov. from Mt Daming, central Guangxi (Fig. 1). Among them, *Nidirana guangxiensis* sp. nov. is phylogenetically close to *N. yaoica*, while *N. xiangica* and *N. leishanensis* are sister species (Fig. 2). The complex rivers and mountainous systems in Guangxi may play as important barriers to the speciation of these species pairs.

As indicated by the etymology of the generic epithet (Dubois 1992), some species of *Nidirana* were observed with the behavior of nest construction (*Nidirana guangxiensis* sp. nov., *N. okinavana*, *N. nankunensis*, *N. hainanensis*, *N. chapaensis*, and *N. daunchina*). According to our field observations, these nest-constructing species usually live in natural swamps and ponds with muddy bottoms (Fei et al. 2009, 2012; Lyu et al. 2017; this work). Such habitats obtain seasonal rainfall and unpredictable water accumulation, which implies that constructing a nest would be helpful for the growth of the eggs and tadpoles. In contrast, the congeners without such behavior (*N. adenopleura*, *N. guangdongensis*, *N. leishanensis*, *N. lini*, *N. mangveni*,



Figure 9. **A** habitat of *Nidirana guangxiensis* sp. nov. in the type locality in Mt Daming **B** a male calling in a nest and two nests filled with half of water. Photos by Yun-Ming Mo and Shuo Qi.

N. occidentalis, *N. pleuraden*, and *N. xiangica*) usually inhabit natural or artificial ponds and paddies with perennial water, which allows them to directly oviposit into the water (Fei et al. 2009, 2012; Lyu et al. 2020a, 2020b). Additionally, the nest construction behaviors of two other congeners are still unknown (*N. yaoica* and *N. yae*; Table 2), but to roughly illustrate and compare the reported ecological data which is correlated to such courtship behavior, *N. yaoica* living in seasonal swamps (Lyu et al. 2019) is likely to construct nests, and *N. yae* inhabiting paddy field with tadpoles observed at the water surface (Wei et al. 2020) may not possess such behavior. Regarded as important for breeding, this behavior was used for the species-group

divisions (Fei et al. 2009; Chuaynkern et al. 2010). Nevertheless, Lyu et al. (2019) revised the species groups based on phylogenetic results and found that the behavior of nest construction seems to evolve independently in different clades. As an infrequent habit in the family Ranidae, the evolution of nest construction behavior in *Nidirana* species would be a topic worth studying and requires more ethological and ecological work and the application of genomic data.

Based on the phylogenetic relationships, Lyu et al. (2017) partitioned the genus *Nidirana* into four robustly supported clades (Fig. 2). Clade A corresponds to the *N. pleuraden* group with two recognized species (Lyu et al. 2019, 2020a), while the other clades belong to the *N. adenopleura* group (Lyu et al. 2019). Clade B is monotypic and includes only *N. lini*, clade D is comprised of four species, and clade C includes nine species which are more than half the members of the genus. By bringing the phylogenetic analyses from this work and previous studies (Lyu et al. 2019, 2020a, b), the interspecies relationships within clade C are unclear due to the relatively lower supported values in mitochondrial genes. Species of clade C are mostly distributed in the hilly regions throughout southwestern and south-central China and northern Indochina (Fig. 1), at the edge of the Indo-Burma biodiversity hotspot. In view of the extensiveness of these hilly areas and the unclear relationship within this clade, *Nidirana* diversity in these areas seems still underestimated, which suggests that further surveys are required.

Acknowledgements

We thank Wei-Liang Xie, Zhao-Chi Zeng, Shuo Qi, Jian Wang, Pi-Ning Zhou, Min Shao, and Xi Hu for their help in the field and lab. We thank Yinpeng Zhang and Robin Moser from Michigan State University for polishing the language. This work was supported by National Animal Collection Resource Center, China, and Guangxi Natural Science Foundation (grant no. 2017GXNSFDA198001).

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Appendix I

Specimens examined

- Nidirana adenopleura* (37): **China: Taiwan:** Taichung City: SYS a007358–7365; **Fujian:** Yanping District: SYS a005911–5916; Mt Wuyi: SYS a005939–5943; Jiashengshi Nature Reserve: SYS a004112, 4132; Mt Yashu: SYS a005890–5891, 5901–5902; **Jiangxi:** Tongboshan Nature Reserve: SYS a001663–1665, 1667, 1698; Yangjifeng Nature Reserve: SYS a0000317, 0334; Jinggangshan Nature Reserve: SYS a004025–4027; **Zhejiang:** Jiaxing County: Dongkeng Town: SYS a002725–2726.
- Nidirana daunchina* (5): **China: Sichuan:** Mt Emei: SYS a004594–4595 (topotypes); Hejiang County: Zihuai Town: SYS a004930–4932.
- Nidirana guangdongensis* (8): **China: Guangdong:** Shimentai Nature Reserve: SYS a005765–5767, 5995, 5997–5998, 6879, 7688 (holotype and paratypes series).
- Nidirana hainanensis* (4): **China: Hainan:** Mt Diaoluo: SYS a003741, 7669–7671 (topotypes).
- Nidirana leishanensis* (13): **China: Guizhou:** Mt Leigong: SYS a007908 (topotypes); Mt Fanjing: SYS a007195–7196; **Guangxi:** Mt Jiuwan: NHMG 202007021–023, 025–029, 042–043.

- Nidirana lini* (4): **China: Yunnan:** Jiangcheng County: Hongjiang Town: SYS a003967–3970 (topotypes).
- Nidirana mangveni* (9): **China: Zhejiang:** Mt Dapan: SYS a006310–6314; Mt. Longmen: SYS a006413–6414, 6416; Hangzhou City: SYNU 12050569 (holotype and paratypes series).
- Nidirana nankunensis* (12): **China: Guangdong:** Mt Nankun: SYS a003615, 3617–3620, 4019, 4905–4907, 5717–5719 (holotype and paratypes series).
- Nidirana occidentalis* (8): **China: Yunnan:** Mt. Gaoligong: SYS a003775–3778; Shuangjiang County: SYS a007829–7832 (holotype and paratypes series).
- Nidirana pleuraden* (16): **China: Yunnan:** Kunming City: SYS a007585 (juvenile individual, topotype); Wenshan City: SYS a007717–7723, 7730; Xinning County: SYS a007767, 7769–7770; Shiping County: SYS a007786–7789.
- Nidirana xiangica* (10): **China: Hunan:** Mt Dawei: SYS a006491–6493; Mt. Yangming: SYS a007269–7273; **Jiangxi:** Mt Wugong: SYS a002590–2591 (holotype and paratypes series).
- Nidirana yaoica* (13): **China: Guangxi:** Mt Dayao: SYS a007009, 7011–7014, 7020–7022, NHMG 1503043–047 (holotype and paratypes series).